Improving the Spatial Resolution of Snow Albedo Measurements in Mountainous Regions Using a Dual-sensor Unmanned Aerial Vehicle (UAV)

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Mountains & Minds

The National Academies of Science identified the importance of snow albedo and its physical controls in the Targeted Observables of the 2017 *Decadal Strategy for Earth Observation from Space*.

Broad-scale measurements of the Earth's surface from space and air require near-Earth measurements to calibrate and validate the signals recorded [1–4], regardless of the platform or mission.

However, the scaling issues that exist between in situ and Earth Observation data generate challenges in the calibration and validation of measurements, especially with satellite measurements [5,6].

Current ground-based/near-Earth approaches to measure albedo are limited primarily to fixed-location towers or manual field surveys.

This limits the ability to measure the inherent variability of albedo that exists across the broader landscape [1,3–5].

Can UAVs provide high resolution measurements of snow albedo across mountain landscapes?

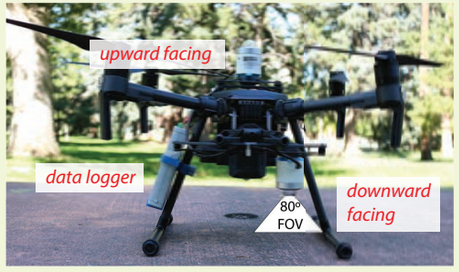
Design and fabrication of a replica sensor and mount using CAD and a 3D printer

Kipp & Zonen SMP3
(modified pyranometer)

Spectral range
300 - 2800 nm

80º FOV

0.386 kg



DJI Matrice 210V2
Quadcopter

1.34 kg payload capacity

0.78 kg payload deployed

15 - 20 min/flight

Calibration and testing

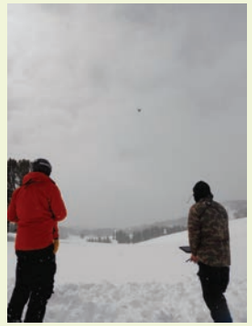
Agreement between upward and downward facing sensors (landing gear present)
$R^2 = 0.995$
Mean Absolute Error = 24.0 Wm^{-2}
Mean Absolute Error% = 3.15%

Downward-facing measurements were calibrated by a factor of 1.0287 for the presence of landing gear.

1. Wang, Z., et al.; Evaluation of MODIS albedo product (MCD43A) over grassland, agriculture and forest surface types during dormant and snow-covered periods. Remote Sens. Environ. 2014, 140, 60–77, doi:10.1016/J.RSE.2013.08.025.
2. Kharbouche, S., et al.; Assessment of Satellite-Derived Surface Reflectances by NASA's CAR Airborne Radiometer over Railroad Valley Playa. Remote Sens. 2017, 9, doi:10.3390/rs9060562.
3. Levy, C., et al.; Novel Measurements of Fine-Scale Albedo: Using a Commercial Quadcopter to Measure Radiation Fluxes. Remote Sens. 2018, 10, 1303.
4. Bair, E. H., et al.; An examination of snow albedo estimates from MODIS and their impact on snow water equivalent reconstruction. Water Resour. Res. 2019, doi:10.1029/2019WR024810.
5. Román, M., et al.; The MODIS (Collection V005) BRDF/albedo product: Assessment of spatial representativeness over forested landscapes. Remote Sens. Environ. 2009, 113, 2476–2498, doi:10.1016/J.RSE.2009.07.009.
6. Román, M., et al.; Use of in situ and airborne multiangle data to assess MODIS- and Landsat-based estimates of directional reflectance and albedo. IEEE Trans. Geosci. Remote Sens. 2013, 51, 1393–1404.

Flights

Flights 1 & 2

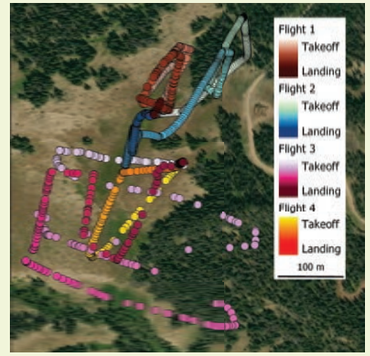


April 15, 2019
Windy, snowy and cloudy
10 cm of snow in past 24 hours

Flights 3 & 4

May 1, 2019
Clear and calm
5 cm of snow 48 hours prior

Flights conducted just outside Yellowstone National Park at ~2650 m.s.l.



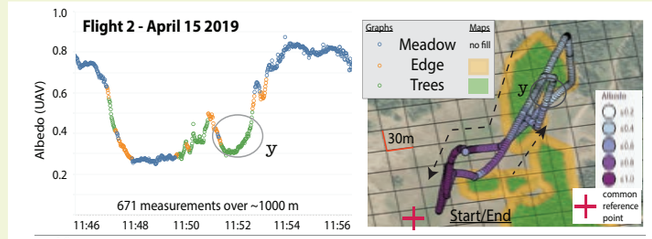
Challenges and Successes

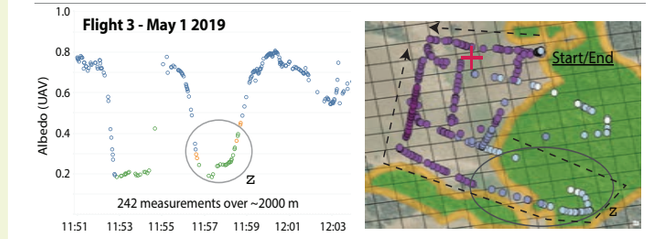
During the spring of 2019, the Matrice 210 V2 did not have functioning flight planning software available.

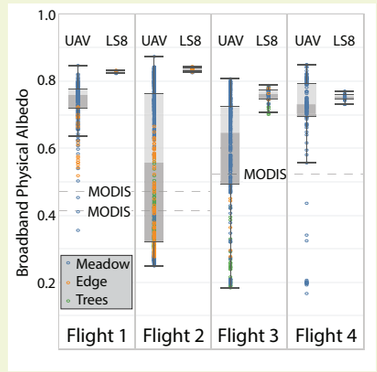
The high-resolution camera for the Matrice 210 V2 was backordered, thus all navigation was conducted manually using the onboard field-of-view camera.

The UAV performed well during flights, was stable and easily navigable in snowy, windy conditions.

Results







Wrapping up

It works and measures albedo in snowy-mountainous terrain.

The albedo data derived from flights clearly differentiates land-cover changes across the landscape.

Landscape variability is not distinguishable in corresponding satellite data.

Flights during the winter of 2019/2020 will provide more detailed data to quantify the scale dependent controls on albedo, and incorporate atmospheric corrections.

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